The "Wing Warping" Controversy

A Centennial WebQuest for Grades 7-12

Article I; Section Eight: The United States Constitution:

Congress shall have the power …*To promote the progress of science and useful arts, by securing for limited times to authors and inventors the exclusive right to their respective writings and discoveries.*

(Did the Wright Brothers hold back aviation? Some say they did! Were the Wright's wrong? Debate and decide.)

Introduction and Background:

Wilbur and Orville Wright together discovered the secret to flight. Of this there can be no doubt today. However, it took until 1947 for the Smithsonian Institution in Washington DC to display the Wright Brothers *1903 Flyer* as the world's first airplane!

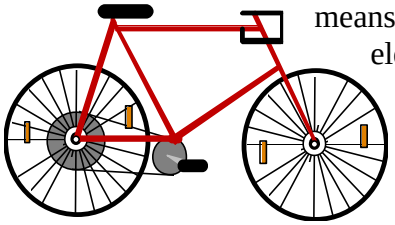
Why? It is said that success has a thousand fathers; if so, many have laid claim to paternity for the airplane. In fact, Orville was so upset with the Smithsonian that he shipped the *1903 Flyer* to the London Science Museum for 20 years. Why again? Because, early on, the Smithsonian did not accept the Wright Brothers claim of being first in the air. They maintained that a former Smithsonian Director, Samuel Langley, had been original with his *Aerodrome*. Eventually, the Smithsonian corrected its error and now the world's first airplane, the *1903 Wright Flyer*, is the centerpiece in the most visited museum in the world, the Smithsonian National Air and Space Museum in Washington, DC.

Ideas: Beyond the question of the being first to fly, which is now settled, there is a stronger assertion made against the Wrights. This claim was made during their lifetime and is now emphasized by some aviation historians. The claim is that the Wright Brothers held back the development of aviation for many years with the **patent** of their invention. This famous patent was not for the *1903 Wright Flyer*. Instead, it was based on the 1902 Glider and it covered the three-axis control system necessary for any flying machine. In other words, the patent did not cover the glider as a machine made of so much cloth, wood and wire, but as the platform for the *ideas* of how to achieve controlled flight, especially the turn, or lateral, sideways movement. The Wright Brothers wanted **intellectual property rights** and made **broad claims** for their invention.

 # 821,393: When Orville and Wilbur received US patent number # 821,393 in 1906 for a *Flying Machine*, it gave them a monopoly over all future flying machines. In essence, they had invented a new technology. They wanted money, **royalties**, from all other airplane designers who used their ideas, their hard won intellectual property. They did not look kindly upon anyone who stole from them in business, be it a bicycle from their shop or an idea from their heads! The Wrights sued anyone who used their ideas without

their permission or without the payment of a royalty. Their rivals said this was unfair and that the Wright's legal action held back the development of aviation and perhaps even held back the Wright Brothers themselves from the development of new inventions in aviation because they had to spend so many years in court battles. Who is correct? Were the Wright's wrong? This question is the subject of this WebQuest. Since others from the United States and Europe were soon busy making airplanes, this meant that the Brothers had to spend many years filing law suits against others who had "infringed" (*to break down, or breach*) their claim. This legal strategy took time and energy and led to bitterness with rivals, and even anger from some friends. These legal trials exhausted Wilbur and contributed to his early death in 1912. Orville was forever embittered by the patent battles and blamed one American rival in particular: *Glenn Curtiss.*

Bikes and Balance: The Wrights believed that the three important things about building a successful airplane were wings to give it lift, a motor to power the propellers, and a means to control the airplane in three dimensions. The last element, control in the air, was the most important factor of all. Wilbur sought dynamic balance and handling in the air. When Wilbur began to study the problem closely in 1899, he searched for "equilibrium" and stability. How would the pilot make a turn in the air? His experience with bicycle design and riding helped. How does the cyclist make a turn on the bicycle? How do you make, say, a **left turn** on a bicycle? It is something you do quickly and effortlessly, but what are the steps involved? How would you describe the entire process to someone who has never been on a bicycle?



Think about this for a while.

Write out the steps, or sketch them in stages. To turn to the left do you yank or jerk the handlebars to the left suddenly? Does the bicycle remain perfectly vertical, or perpendicular, with respect to the ground? Do you lean forward or back, or to one side? If so, in what direction(s) do you lean and when do you do this as part of the turn? At the beginning, or later on in the sequence? Do you ever move to the *right* in order to go left? Think even longer! Better yet, get on your bicycle this evening after school and experiment your way through this question. How do you make a **left turn** on a bicycle with equilibrium and stability?

Boxes and Wings: The Wright Brothers had a very detailed idea of how a bicyclist made a left turn. However, how would a pilot make a left turn in the air? To understand the manner in which the Wrights thought this problem through, we need to park the bike and try another simple experiment. This time head for the kitchen.

Take an aluminum foil box, or a wax paper box, into your hands. With one long side resting against your stomach, press the ends lightly with the palms of your hands. The border that faces forward is the *leading edge* and the part resting against your body is the *trailing edge*. Give the box a slight twist with your palm on one side and notice what happens to the other side. Look left and right on the box and notice the leading and trailing edges. Try it again. Think about this for a while.

When the left side's *leading* edge of your box tilts upward (and the *trailing* edge tilts downward), the right side's leading edge tilts downward (and the trailing edge tilts upward).

In 1899, Wilbur was thinking hard about turning, both on the ground with a bicycle and in the air with a glider. He noticed that in order to turn, birds presented the leading edge of one wing at an upward angle and the leading edge of the other wing at a downward angle. He noticed also that birds' wings are strong and flexible and that the turns birds make are balanced. Wilbur knew that his glider would have to be able to twist and flex like a bird to be able to turn. The designs of other experimenters, for example that of Otto Lilienthal of Germany, required the pilot to shift his weight powerfully, and shift the center of balance of the airplane, in order to gain some control. In 1896, Lilienthal lost control and died in a crash. Birds did not shift their weight, Wilbur thought. Birds work with the air and make small adjustments by tilting their wings in order to stay aloft and turn. There has to be a better way to design a man carrying gliders and their wings, he thought. How would he and his brother *engineer* a design that would give them subtle bird-like control and balance in the air? He thought about this day and night and his keen mind was prepared to accept insights from all directions **…**

… While Wilbur was reflecting along such lines, a customer and old friend arrived at the Wright Cyclery Shop one evening in July 1899. Orville was showing visitors around Dayton at the time. This customer wanted an 'inner tube' for the tire of his bicycle. The inner tube came in a cardboard box about the size of the aluminum foil box you just handled. Wilbur made the sale, talked for a while, and nonchalantly fiddled with the ends of the box. His hands felt a twisting motion. He looked at the result of the twist on the top and bottom of the box. It gave him an idea. His hands felt the idea first, then his eye noticed the twist, and finally his prepared brain put the two together.

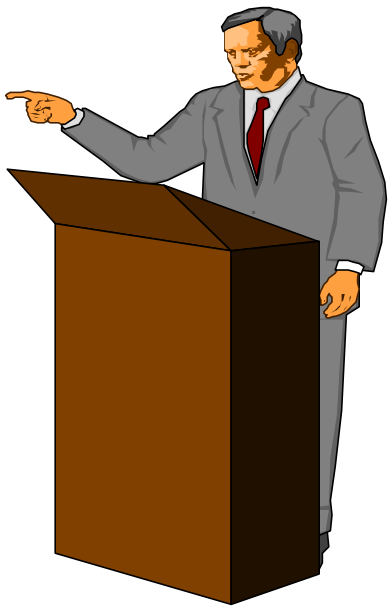
Wilbur told Orville that evening. The top surface of the inner tube box became the top wing of a biplane in his mind, and the bottom surface of the box became the bottom wing of the glider. It was flexible but strong. They constructed a model kite the next day to test out the idea on a small and manageable scale. The idea worked in the air with the model kite and proved that the twisting concept was worth building into all full-scale gliders and flyers. Imagine looking through an empty aluminum foil box that has the ends removed, but the top and bottom sections are still in place, and the sides are braced in vertical sections. This twisting action is also called warping, and when it is applied to an airplane, it is called ***wing warping.*** This technique altered flow of the air differently across the wings and created a difference in lift causing one wing to rise and the other to dip. Notice this animation of the Wright 1901 Glider and you will see how this idea of wing warping with a box was put into action in the attempt to fly: http://www.wrightexperience.com/edu/1901/RandD/ED.htm . To the Wrights the inspiration of the twisting cardboard box eventually led to control in the air, and the ability to turn in the air and recover from the turn when wing warping was directly linked to rudder action. This was essential to their patent #821,393. In fact, Wilbur sent a bicycle inner tube box to a confused patent clerk years later in order to make clear his original inspiration for wing warping, the lateral control of an airplane, the turn.

Glenn Curtiss: The Wright Patent covered lateral control and turning but other inventors wanted to get in on the act. Perhaps there are other ways to turn an airplane, simpler ways than twisting the wings of the plane. The most famous rival and patent infringer was Glenn Curtiss. He designed ailerons as an alternative for his airplanes. Ailerons were *"little wings"* or flaps attached to the wings which acted like wing warping in that it altered the flow of the air differently across the wings and created a difference in lift causing one wing to rise and the other to dip. Did ailerons infringe on the Wright patent? Was it another form of wing warping? The Wright Brothers said Glenn violated the Law of Equivalents in patent law, which holds that one cannot copy the design of another, give it a new name, and then claim it as an original invention. If so, Glenn Curtiss owed the Wrights royalties. If so, he would either have to pay the Wrights, or stop building and selling his planes.

Glenn Curtiss was not an ordinary infringer who wanted to steal the secret of flight and the intellectual property of the Wrights. He came up with his ideas while working with Alexander Graham Bell, the famous inventor of the telephone. Bell was too old to fly when he invited Glenn Curtiss to help him design an airplane. Glenn Curtiss was a brilliant man in his own right when he met Bell. He was a genius mechanic who made his reputation with motorcycles. He designed them for speed, and he set speed records. For example, in 1907 he was declared the "Fastest Man in the World" for traveling 136 miles per hour on a motorcycle. Curtiss was also considered the Father of Naval Aviation because of his invention of the *Hydroaeroplane A-1* in 1911, and other original designs for using airplanes at sea. He invented *flying boats* to cross the Atlantic. By the time he died in 1930, Curtiss produced over 500 inventions.

Bell, Glenn and their supporters felt that the aileron was vastly superior to the Wrights wing warping technique and that their design did not infringe on the Wright patent. They designed the *White Wing* (1907), the *June Bug* (1908), and the *Golden Flyer* (1909) with ailerons. The Wright Brothers wrote to Curtiss and asked him to pay royalties or to stop flying. This led to a long seven year patent war that ended only with the American entry into World War I in 1917. In a great irony, the two companies merged in 1929 to form the Curtiss-Wright Airplane Company, which still exists today!

Today the aileron is used on almost all fixed winged aircraft in order to make turns. Wing warping is not common except on a few highly experimental craft.



The Task:

The Director of NASA has a problem and via email from Headquarters, he has asked for your help. This is the second time he has called you to Washington for help in the last six months, so you know you must be doing something right. You and your group arrive in his office in Washington ready to go. Excitement was in the air. As usual, the "Boss" started talking before the door was closed. He greeted everyone like old friends and got down to business.

"Welcome! Congratulations *on the Wind Tunnel Analysis and the Mars Airplane Report. You proved that you could really dig out the best information from available sources and put it all together in an interesting package. It surely convinced me, and Congress was impressed. They are thinking of going forward with your, err, my, recommendations. We will see if the money is in the budget.*

(My team was pleased and exchanged silent high fives!)

I need your help again. *The other day the Director of the United States Patent and Trademark Office and I were talking about patents and patent protection. We were wondering if 17 years is too long for an invention to be protected given the speed of modern technology. I learned that Ben Franklin never tried to make money off his many inventions. Franklin felt that good ideas should be shared as soon as possible for the good of all. His lightening rod is an example. Now, Ben Franklin earned a fortune doing other things so he could afford to be generous. Most inventors need the incentive of money and the protection of their patents. Do you agree?*

All of the excitement about the Wright Brothers Centennial has sparked interest in innovation and discovery. There was a case before the Supreme Court in 2002 that had to do with patents, patent protection, and inventions. It was called the "Festo" decision; you can look that up for yourselves if you like.

The Festo decision gives a lot of patent protection to inventors. It would have made the Wright Brothers happy. They were very proud of wing warping and it was the idea that allowed them to conquer the air. Whenever I get a chance on my lunch break here in Washington, I like to visit the Smithsonian National Air and Space Museum and feast my eyes on their 1903 Flyer. Did you know that the pilot on the first flight, Orville, actually lay down on the lower wing? They did not get around to sitting upright until 1907! Wheels were much later. The Wrights concentrated on the essentials. Learning to fly was more important to them than anything else was. However, without the incentive to know that their invention would be protected by patent for 17 years, would the Wright's have gone to all of the trouble? I suspect not.

Ailerons are what we use today*, however. History proves that Glenn Curtiss had an even better idea but he may have stolen the basic concept from Wilbur and Orville. The Wing Warping vs. Ailerons battle could have held back aviation. Wing warping lost out because all later designers saw that it was a simpler and a more direct means of control. If Curtiss were alive today, he would have been saddened with the Festo decision. He was proud of his ailerons design, and it was the idea that allowed him to master the air and set many speed records. He would say that 17 years is too long for patent protection. He would also say that his system did not infringe on the Wrights.*

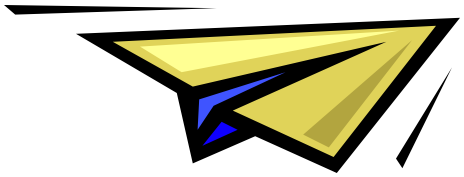
(We all nodded but realized we would have to do a little brushing up on the two systems, and on the Wrights and Glenn Curtiss. But we did not have time to daydream with the Boss starting to come to the point and give us a specific job.)

I need you to research this Wing Warping Controversy question for me but I do not want a report this time. I have something else in mind. Here are your tasks:

Task Number #1:

Research all aspects of this case and come up with a list of facts and findings that are not in dispute. Do this in pairs, or groups of three. Learn as much as you can about:

- Patents
- Patent Protection
- Infringement
- The "Law of Equivalents"
- Intellectual Property Rights
- Ailerons in general
- Wing Warping in general
- Glenn Curtiss and his Ailerons designs specifically
- The Wright Brothers and Wing Warping



Share this information freely with each other … no secrets at this stage. Get together after a week or two of researching and develop a list of facts not in dispute, as the legal people say. You can place these on a matrix or chart if you like. This will be your baseline of information.

Task Number #2:

Divide your group into two teams and take sides. One team should take the side of Glenn Curtiss in this debate. The other team should support the claims of the Wright Brothers. Take a week or two to organize your thoughts and best arguments.

Each team must develop three key arguments in support of their view: two positive arguments to support their side, and one negative (an attack) argument against the other side. Opinions are fine as long as they are anchored in the facts.

I want fresh ideas based on the facts. Who was right in this case and is the 17-year rule too much protection for the 21st Century?

Task Number #3:

In about a month I would like you to hold a one-hour debate in my office. Each side will have 30 minutes to present their best case: 20 minutes for a presentation and 10 minutes for Questions and Answers for dealing with arguments from the other side. The debate will let me draw my own conclusions about technology and change. The Director of the Patent Office and some of his staff will help me see the big picture. You may use charts and graphs, pictures and models, but remember that you only have 30 minutes in all for your side. Make every data point count!

(As we rubbed our hands in anticipation of a good debate the phone rang and the Boss had to take the call. But before we left, he had one last word.)

Boy, I wish I could do this work with you; I miss the excitement of doing research. Thanks for coming in and Good Luck!"

The Process: Cooperation and Evaluation:

1. **For the first fact-collecting Task #1, work in small teams and conduct your research.**

For the sake of organization, it is best to delegate responsibilities. Be sure the class covers all of the topics mentioned by the Director, and others you discover as you move forward.

Work with your teacher to develop a **Wing Warping vs. Ailerons Matrix** of basic facts. All students have to make equal contributions in terms of time and effort. By the end of this two-week fact-building period, individual students, or small teams should produce reports or "deliverables" that can be shared by all. These items should go into the Matrix.

2. **Take sides and establish the best approach to the problem.**

Map out your strategy. Every member of the teams will write and sketch out ideas, complete data tables, support the construction of models, and speak up as needed. Each team will also need the following roles to be filled before launching into the second phase of the WebQuest. Each side should appoint a:

Chairperson to ensure that the team works together as a unit and completes its work on time.

Three Lead Presenters who will make sure the team is answering the key questions posed by the Director. The Lead Presenters/Debaters cover the two positive arguments to support their side, and one negative (an attack) argument against the other side.

Three Anticipators: This team will try to think of how to anticipate the argument of the other side and develop strategies for dealing with it. They will plan the rebuttal or counter arguments for your team.

The Designer and her teammates will have overall responsibility for the "look and feel" of the poster boards, demonstrations, or PowerPoint presentations imparting these ideas.

The Editor and his team will give unity and editorial polish to the final written product or briefing paper. The Director and his panel of experts from the Patent Office will be looking for clarity and organization. Write to convince.

Everyone will be responsible for doing his or her fair share.

3. Start you web research and build presentation models as needed.

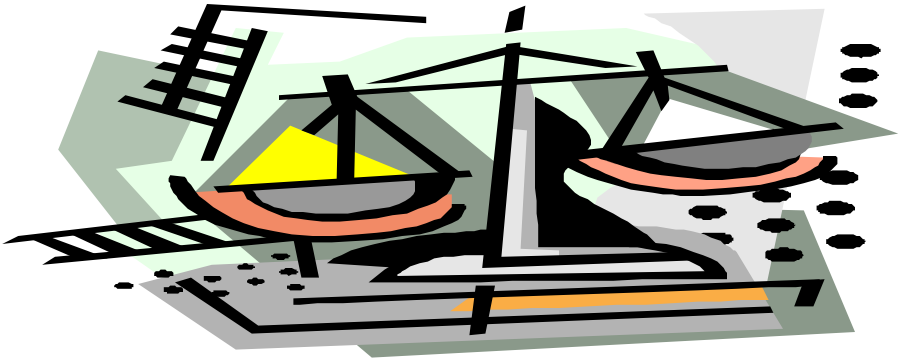
The *Student Resources Page* has several links for you to consider. As with all Internet searching one link leads to another and you may discover items the Web Quest designer never noticed. Select the sites that will help you find direct proof so you can come up with answers you can trust. The Chairperson should always keep the big picture in mind: *Determine the best lines of reasoning to present in 20 minutes to convince the Director of the logic of your team. In addition, the Anticipators should think like the other team and be ready to provide a detailed rebuttal during the 10 minute Question and Answer section. They will have to think on their feet; to do this they must be well prepared.*

4. Plan the presentation.

A "beginners mistake" common among teams is to wait until the last minute to actually put together the final presentation. Do not wait until it is too late and you are rushed. The Designer and Editor should look ahead and express a clear and concise format for delivering your conclusions.

5. The Final Deliverable: Show, don't tell!

The Director is looking for proof of web-based research and hands-on experiments that come from that research. Show your results in an interesting and organized fashion. Be sure to answer his question about the 17-year rule. Is it still a good idea for our modern times?



Student Resources:

The resources below will be the most help in your **Wing Warping vs. Ailerons Debate** WebQuest. Check out each one. However, this list is not complete, no more than the

Internet is ever finished or complete. If you use a favorite search engine and carefully define your search, you may locate new resources on the topic. If so, share them with your teacher. Given the nature of the Debate, you might find some links and resources that you will not want to share with the other team. That is fine for this WebQuest Debate activity: good research will help your team on this task. At times, your teacher will call you together in teams for discussions, or perhaps just meet with the Chairperson, Designers, Editors, the Presenters, or the Anticipators. Your teacher will also advise you in the construction of any models to aid in your presentation. Good luck in your debate!

Some Suggested Sites:

Wright Brothers:

Centennial of Flight Commission. *Educational Resource Matrix:* A master, multi-layered resource for teachers and students with sites from government, industry, and organizations. If you like to have one place to start when beginning your search for materials, then this portal is for you.
http://www.centennialofflight.gov/matrix_intro.htm

Centennial of Flight Commission. *Wright Brothers History Page*: In order to understand the achievement of the Wright Brothers in context, start with this page about their life and times. Several links are positioned here. Be sure to note the "Wright Brothers, 1899-2003" link in the left margin.
http://www.centennialofflight.gov/1903.htm

"How We Made the First Flight" ... by Orville Wright: Why not read about the process of invention from one of the Wright Brothers directly? Wilbur was in Europe at the time and could not contribute, but he thought his younger brother did a fine job of telling their story. This is a very readable account of what the Wright Brothers accomplished at Kitty Hawk. The illustrations are appealing also.
http://www.aero-web.org/history/wright/wriframe.htm

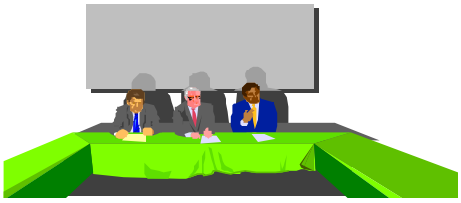
The Wright Experience: *Inspired by an Inner Tube Box:* The Wrights were bicycle mechanics and sold everything for the bike rider. How could a simple box have mattered? This is a sample page from the Wright Experience site. Be sure to click on the word "NEXT" in order to learn more. The animation is compelling and it sets up a fuller understanding of the upcoming reference.
http://www.centennialofflight.gov/history/controls/control/ED.htm

The Wright Experience. *An Unusual System:* This enlarges the theme of the "Inspired by an Inner Tube Box" page above, and shows how the twisting of a bicycle inner tube box led to a flexible wing biplane. Animate the image with the "NEXT" prompt.
http://www.centennialofflight.gov/history/controls/F19/ED.htm

Patents:

US Patent and Trademark Office (USPTO) This is an excellent starting point for looking into patents. Click on "Activities and Education."
http://www.uspto.gov/

USPTO FAQ's: This section is designed for kids.
http://www.uspto.gov/go/kids/kidprimer.html



Patent and Trade Secrets: An excellent overview on what constitutes and Invention.
http://www.jurisdiction.com/patweb02.htm

Digital Library: An excellent general source to papers on early aviation
http://invention.psychology.msstate.edu/library/source.html

An excellent timeline that relates to the Wrights and their rivals:
http://www.wright-brothers.org/History/Wright%20Story/showingworld.htm

An image of the famous 1906 "Grandfather" patent granted to the Wrights:
http://www.wright-brothers.org/History%20Images/Patent%201906.JPG

Glenn Curtiss:

The Centennial of Flight on Glenn Curtiss
http://www.centennialofflight.gov/essay/Dictionary/Curtiss/DI19.htm

Glenn H. Curtiss Museum
http://www.linkny.com/CurtissMuseum/

All about Glenn Curtiss
http://www.glenncurtiss.com/

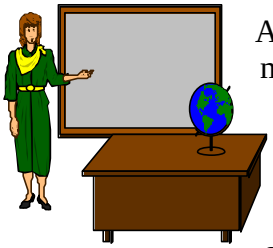
This site calls Glenn Curtiss the Henry Ford of Aviation.
http://glennhcurtiss.com/

This will help keep the timeline organized: it will tell you who was doing what, when, and where. Click on a year for more detail.

Notice the ailerons between the two wings of this biplane?
http://www.1910dominguezmeet.com/curt2a.htm

The modern Curtis-Wright Corporation:
http://www.curtisswright.com/

Teacher and Parent Resources:



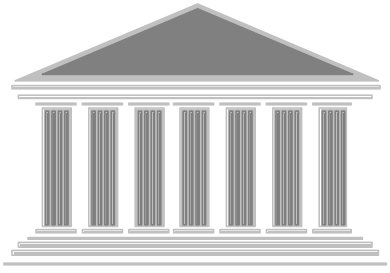
A WebQuest is an activity that can vary in scope and scale. What makes it different from regular curricular resources is that most of the information needed to answer the questions from the prompt can be found through online resources linked above. We suggest having the students work in teams as described above to allow for concentrated but distributed responsibility for the debate. The classroom ground rules you have established for online research, working in teams, doing homework, fair sharing, and reporting out to the larger class should obtain for this endeavor also.

These activities are intended for students in the 7th to 8th grade band. With a few moderations, this WebQuest is also available for students in the 9th to 12th grade is considered in terms of a classic debate. The research possibilities will lead to many interesting insights for either side. Diligence will matter! It can be conducted in schools or with home-schooled students in an assembly.

- **The Director:** A local scientist, the principal, a science coordinator, or colleague might like to serve as the *Director of NASA.* He or she could use the text above as a sort of script, present the task, this WebQuest, to the class, and then return in a month to hear and evaluate the results. The Director could send email on occasion to each Chairperson to give advice and encouragement, or nag about deadlines! After all, he is the boss. Perhaps this person of generous volunteer spirit could make an appearance with a few friends (NASA and Patent Office technicians) to help construct the models and debating props, and make general suggestions.

- **Patent Panel:** Highly suggested is a panel of five or seven adults to hear the debate. The Directors should be present as well as a local scientist or inventor. Perhaps the school principal will be available. Retired teachers would be ideal. Check with the Speech and Debate coach at your school for ideas.

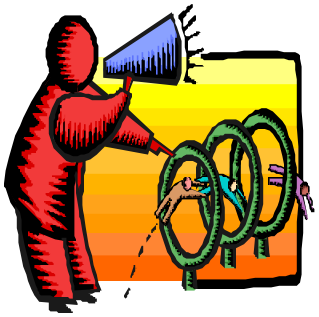
- **Location and Setting:** The classroom is fine but consider an auditorium, or an evening presentation offsite at a local public building. This can add great anticipation for the students (albeit with great pressure for the teacher). If the preparation of the students is well honed, then a larger or remote venue might be very rewarding for all involved. This decision depends on the amount of attention and visibility you want to give to the activity, and to your experience as a teacher. As with so much else in education, it is a judgment call.



Thank you for considering this NASA Wright Brothers Centennial WebQuest, and thank you for all that you do for your students everyday of the school year.

National Standards

The National Science Education Standards for Grades 5-8.
http://books.nap.edu/html/nses/html/6d.html



The National Science Education Standards for Grades 9-12.
http://books.nap.edu/html/nses/html/6e.html

The National Council of Teachers of Mathematics Standards for Grades 6-8.
http://standards-e.nctm.org/document/chapter6/index.htm

Grades 7-12 :
http://standards-e.nctm.org/document/chapter7/index.htm

> ***Data Analysis:***
> **Formulate questions that can be addressed with data and collect, organize, and display relevant data to answer them**
>
> ***Representation:***
> **Instructional programs from prekindergarten through grade 12 should enable all students to—create and use representations to organize, record, and communicate mathematical ideas; select, apply, and translate among mathematical representations to solve problems; use representations to model and interpret physical, social, and mathematical phenomena.**

National Technology Standards

http://cnets.iste.org/

> **Standard 4:** ***Students will develop an understanding of the cultural, social, economic, and political effects of technology.***
>
> **Standard 5:** ***Students will develop an understanding of the effects of technology on the environment.***

Standards for All Subject Areas and in All States: A Master Listing by NASA

http://education.nasa.gov/k12.html